PATENT SPECIFICATION (11) 1 386 645

(21) Application No 46696/72 (22) Filed 10 Oct. 1972
(31) Convention Application No. 2848/71 (32) Filed 11 Oct. 1971 in
(33) Finland (SF)
(44) Complete Specification published 12 March 1975
(51) INT. CL.[2] B22D 19/00 23/04
(52) Index at acceptance
B3F 16A158 16A66 16B2BX 16B2D 16B3 16B5 6B3

(19)

1 386 645

(54) METHOD OF CASTING COOLING ELEMENTS

(71) We, OUTOKUMPU OY, a Finnish Body Corporate of Outokumpu, Finland, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to a method of manufacturing cooling elements for use in different heat treatment furnaces and to cooling elements so manufactured.

Cooling is generally used in smelting and annealing furnaces to protect areas which are subjected to particularly great heat loads. This cooling can be obtained, for example, by blowing air onto the outer surface of the masonry or the metal mantle surrounding it. It is also possible to cool the metal mantle by suitable exterior watering.

When these cooling methods are not applicable due to, for example, the shape of the apparatus, or when their cooling efficiency is not sufficient to protect the critical areas, suitable cooling devices must be designed for these areas at the planning stage of the apparatus.

Usually such devices are separate metal pipes or suitably shaped pipe loops meant for conducting a cooling medium. Depending on the temperature, they can be bare or protected with masonry.

Furthermore, certain parts of the apparatus can be constructed so that they themselves contain the necessary channels for the cooling medium. It is a known method to use so-called cooling ribs in, for example, machine parts which are subjected to a cooling air flow created by a temperature gradient or by a blower. In areas where high temperatures must be used, for example in smelting furnaces, in conjunction with a corroding effect of smelts on the lining of the furnaces, and where liquid cooling must be used for sufficient cooling efficiency, special requirements must be set for the cooling medium channels in regard to their durability with regard to sealing tightness, as the liquid must not come into contact with the smelt, and cooling efficiency.

A sufficiently efficient and durable cooling has not been obtained with conventional cooling pipes in some smelting furnaces subjected to high heat loads (high temperatures) and chemical corrosion with simultaneous mechanical wear and tear, because the cooling pipes used need to be fitted quite close to each other and their walls need to be thick to guarantee a sufficient mechanical durability. It is difficult to shape such thick-walled pipes to fit all necessary areas and, for example, it is difficult to protect them with masonry since the placement of outlet and inlet pipes for the cooling medium causes difficulties.

It has been noted that a continuous cooling element which is cast from metal, which can be shaped to fit the structure of the apparatus and which has sufficient channels for the cooling medium is advantageous in protecting critical areas. For example, a suitably placed cooling element which prevents the wear and corrosion of the masonry may greatly extend the life of the masonry.

So far, the manufacture of such cooling elements has been difficult because they must be provided with cooling medium channels. Special requirements are set for the placement of the channels in the element and on the sealing tightness of the channels, because in principle it is advantageous to make the cooling elements themselves as thin as possible, avoiding unnecessary thickness of material.

For reasons of casting technology, cooling elements which are cast in the conventional manner and in which the cooling medium channels are obtained by means of cores must often be designed so that they do not represent the best and simplest solution from the cooling point of view.

The cooling medium channels should also be as advantageous as possible in regard to the mechanics of flowing, for example the inner surface of the channels should be smooth so it is preferable for there to be no casting pores and no residue of the cores. The channels should also be absolutely tight so that the cooling medium cannot discharge into the smelt space and cause accidents. Furthermore, the heat transfer of the cooling elements should be effective and it should take place evenly over the entire area to be cooled. Consequently, a continuous cooling element of which the entire surface is capable of heat transfer with the same efficiency is naturally the best. This requires a correct placement of the cooling medium channels in the element itself.

The surface area represented by the cooling medium channels compared with the surface area of the entire cooling element can vary to a certain extent, depending on the amount of heat to be transferred and on how high the temperature of the cooling medium removed from the cooling element is allowed to rise. The required surface area is also dependent on the heat conductivity of the cooling element, for example a cooling element made from copper requires less cooling pipe surface than a cooling element of the same size made from iron, because the heat conductivity is better than that of iron.

According to the present invention there is provided a method of making a metallic element having one or more internal channels, such method including the steps of casting molten metal in a mould, thereafter immersing a prefabricated metal pipe corresponding to the or each internal channel in the molten metal and allowing the or each pipe to he heated by the molten metal so that the outer surface of the or each pipe melts, and thereafter allowing the casting to solidify forming a metallic joint between the cast metal and the or each pipe, wherein the or each pipe is cooled while the molten metal is cast and until the casting has solidified.

The invention also provides elements made by the above method.

Thus, the cooling medium channels used in the cooling element are prefabricated pipe which remains inside the casting after a cooling element is cast, and which simultaneously acts as a mould for the element and remains as a cooling medium channel in the cooling element after the casting. It is smooth and with a clean surface, and no core needs to be removed.

The metallic joint created between the prefabricated pipe(s) and the metal solidifying from the metal melt, ensures an efficient transfer of heat all around the cooling pipe with no local distortions. This metallic joint is obtained because the outer surface of the prefabricated pipe(s) is or are allowed to heat up under the influence of molten metal during the casting to such a high temperature that a thin layer of the pipe wall melts, and when the casting solidifies, a metallic joint is formed between the cast metal and the pipe.

To control the melting of the outer surface of the pipe(s), these are suitably cooled during the casting of molten metal by conducting air and/or water or some other cooling liquid through the pipe.

In order to obtain a sufficient cooling efficiency it is advantageous in some cases to allow the water or other liquid used for cooling to vaporize, in which case the highest possible cooling effect is obtained per inner surface area unit of the pipe, when care is taken that the emerging vapour is saturated. This can be best achieved so that a small portion of the liquid is present in the vapour in the form of drops.

During the casting of a cooling element, the temperature of the metal to be cast must usually be higher when the area of the outer surface of the pipes which will become cooling medium channels is large in relation to the amount of metal to be cast. This is because the heat needed to melt correctly the pipe outer surfaces before the entire cooling element may cool is increased, and too low a pouring temperature of the molten metal results in a sufficiently good metallic joint not being obtained.

The following procedure is practical in casting very large cooling elements, especially when there are relatively few cooling medium channels in the element and it would be difficult to provide a sufficiently effective cooling for the pipes which are in the mould as such: a metal layer is built up around the pipes which will become cooling medium channels, by solidifying from molten metal, while providing suitable cooling on the pipe interiors in order to create a suitable joint before the final casting.

When sufficient cooling in connection with casting is uncertain, for example when for some reason the casting temperature of the metal cannot be raised enough because exact control of the cooling during the casting would be difficult, the following procedure can be applied: a thread of a suitable thickness made from the metal to be cast is wound around the pipe, during the casting this thread will melt and form a metallic joint. The diameter of the thread can for instance be almost the same as the thickness of the pipe wall.

In accordance with the present invention the pipe which will become a cooling medium channel is immersed, while being cooled, in molten metal which has been

cast into the mould, such a method is open casting.

An efficient heat transfer by means of a cooling medium requires a homogeneous structure of the cooling element. As few casting pores as possible should be provided, and preferably there is no seam between the prefabricated pipe working and the cast metal. This requires a metallic joint wherein the pipe and the cast metal have been bound to each other with a metallic joint (as in welding or soldering).

In certain cases, when the prefabricated pipe(s) and the cast material of the cooling element itself are of different metals, a layer of some suitable third metal can be formed on the pipe surface to create a metallic joint between the two metals. This intermediate-layer metal can be attached onto the prefabricated pipe surfaces electrolytically, or by soldering, or by dipping the pipe into a melt, or by hot spraying. When the molten cast metal contacts this metal layer on the pipe surface, a metallic joint is created in the mould with this third metal on the pipe surface.

By the method in accordance with the invention it is also possible to manufacture a cooling element which is such that the ends of the cooling medium channels extend beyond the elements at suitable points so that the inlet and outlet pipes for the cooling medium can be easily attached to them.

After casting, the cooling element forms a continuous metal piece consisting of continuous metal from the outer surface of the element to the inner surface of the pipe, in which case the heat conductivity of the element is dependent on the heat conductivity of the metal.

When the protective masonry of a cooling element under particularly strenuous conditions wears out completely owing to combined mechanical and chemical corrosion, a cooling element of this type will form for itself a new protective layer from the material smelted in the furnace. Thus, owing to the cooling elements, the operational period of the furnace between the times of laying new masonry is multiplied in comparison to a furnace working without cooling elements.

An example of cooling elements of the invention are copper cooling plates which are manufactured by the method of the invention and which are used in a flash smelting furnace for copper — or in its modifications. With these cooling plates the durability of the masonry of the reaction shaft and the settler part have been designed for the period required by the process circumstances. In a furnace such as this the surface area of cooling elements may amount to several tens of square meters.

It has been noted that, owing to their good heat conductivity, cooling elements made of copper are very advantageous in, for example, the smelting furnaces for copper concentrates in which the corrosive effect of slag materials at a high temperature (1300°C) combined with mechanical wear and tear is very strong.

Casting a compact piece from copper is known to be difficult, and therefore provisions must be made at the planning stage of the casting for the gases separating from the metal during the casting to escape from the metal in the mould or to remain as such in the part of the metal which remains molten longest and which is removed from the final product after casting.

When placing a cooling pipe system in a cooling element, casting technology factors must also be taken into consideration. A pipe which will become a cooling medium channel must not be placed in an area where the casting solidifies before the melting of the outer surface of the pipe necessary for the formation of a metallic joint has occurred.

The principle is that the casting mould is constructed so that, while the pipe is being cooled in the mould, the casting of molten metal takes place co-currently with the cooling, in which case the difference of temperature caused by cooling between the pipe and molten copper is less in the part of the mould where the temperature of molten copper has decreased.

A cooling pipe placed in the mould lengthens during the casting. Therefore, plates which guide sliding must be installed in the casting mould to keep the pipe in the right position in the mould while allowing a movement caused by heat expansion in the longitudinal direction of the pipe.

The guide plates should be of the same material as the pipes or of some other metal which will not cause corrosion when remaining in the product of casting.

The cooling water if provided can be measured into funnels by means of valves. When large pieces are cast, steam pressure created inside the pipes slows down the water flow. Water is kept in the funnel all the time, and steam pressure then regulates the flow of cooling water into the pipe.

When small cooling elements are cast, the emerging steam formed from cooling water is observed. It must contain drops. If the number of drops increases, water flow is decreased and vice versa.

The pipe which is being cooled must be open at both ends to prevent the formation of pressure in the pipe because a copper pipe at the casting temperature cannot withstand pressure.

Molten copper which is in the casting ladle must not be poured into the mould

before all gases have escaped from the smelt.

From rising holes for metal provided in the mould in connection with moulding it can be observed whether there is a sufficient amount of metal in the mould. Water-cooling should be continued as long as steam formation takes place.

The cooled casting can be tested by a water pressure of 30 kp/cm^2 to detect possible leaks.

Cooling elements of different sizes can be easily obtained by the open casting described above. Furthermore, the side facing the mould (the lower side) will then become very dense (free of pores) and therefore, when the element is used, this side can be placed against the hot side, for example, facing the molten metal or slag.

A chill mould can be used which is made with open casting from cast-iron. It is dimensioned according to the largest element to be cast. This element will probably be plate-shaped, that is, relatively thin and, for example, rectangular. The height of the rims of the mould are preferably the desired thickness of the element.

In use according to the invention, in one form, the mould is heated from the bottom until all water is removed. The hot mould is then painted with fine quartz dust sludge which contains waterglass 2% of the weight of the water, in which case the water of the lubricant evaporates quickly and the quartz dust is attached evenly to the mould. The prefabricated pipe system is attached with copper thread to a so-called yoke in the casting mould and lowered into the mould where it is allowed to pre-heat. For the casting, an amount of molten copper refined until free of oxygen, about 1 1/2 times the amount required for the casting, is taken into a casting ladle. After waiting until the gas formation from the molten copper in the ladle is completed, the metal is cast into the mould from which the pre-heated pipe system, attached to the yoke, has just been lifted.

The copper is allowed to cool in the casting mould, and the moment when the pipe system is immersed in the molten copper in the mould is determined on the basis of the cooling period, and its depth is also determined on the basis of the cooling period. These two factors must be discovered experimentally.

Any copper threads in the yoke which have been attached to the base plate melt immediately, and the pipe system is kept in its place by means of the base plates until the metal is solidified. The ends of the base plates can be cut into a conical shape so that they can be detached from the solidified metal.

To get the cooling pipe system in the right place in the element, adjustable guides can be built on the sides of the casting mould to keep pipe ends which remain outside the casting at the desired point.

If smaller pieces of different lengths and widths are desired, the part of the mould where molten metal is not wanted can be filled with a fireproof material or brick.

Such a cooling plate made in open casting can then be pressed to the desired shape by hydraulic pressure.

WHAT WE CLAIM IS:—

1. A method of making a metallic element having one or more internal channels, such method including the steps of casting molten metal in a mould, thereafter immersing a prefabricated metal pipe corresponding to the or each internal channel in the molten metal and allowing the or each pipe to be heated by the molten metal so that the outer surface of the or each pipe melts, and thereafter allowing the casting to solidify forming a metallic joint between the cast metal and the or each pipe, wherein the or each pipe is cooled while the molten metal is cast and until the casting has solidified.

2. A method according to claim 1, wherein the or each pipe is cooled internally with a liquid.

3. A method according to claim 2, wherein the liquid is flowed through the or each pipe at such a rate that substantially all of it is vaporised.

4. A method according to claim 1 or 3, wherein the or each pipe is cooled internally with air.

5. A method according to any preceding claim wherein the casting temperature is decreased as the ratio of metal cast to the metal in the prefabricated pipe or pipes increases.

6. A method according to any one of the preceding claims wherein the prefabricated pipe(s) are dipped in molten metal which is then solidified prior to being placed in the mould.

7. A method according to claim 6, wherein the pipe(s) are cooled during such dipping.

8. A method according to any preceding claim wherein a thread or coil of the same material as the pipe is wound round the or each pipe prior to location in the mould.

9. A method according to any one of the preceding claims, wherein the pipe(s) and the molten metal are of different metals, and wherein an intermediate layer is provided on the exterior of the pipe(s), prior to immersion, said layer being of a metal suitable for providing a metallic joint with the pipe(s) and molten metal.

10. A method according to claim 9,

wherein the layer is provided electrolytically, by soldering, by dipping or by spraying.

11. A method according to any one of the preceding claims wherein the or each prefabricated pipe is located in the mould on guide plates.

12. A method of making a metallic element having one or more internal channels, such method being substantially as hereinbefore described.

13. A metallic element made by a method according to any one of the preceding claims.

J. A. KEMP & CO.,
Chartered Patent Agents,

14 South Square,
Gray's Inn,
London WC1R 5EU.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1975. Published at the Patent Office, 25 Southampton Buildings, London. WC2A 1AY, from which copies may be obtained.